

# ON THE LOWEST TEMPERATURES ON EARTH

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## ABSTRACT

Records on absolute minima of air temperature on the earth are analyzed geographically and in the course of time. A great deal of controversy is clarified and misleading references to incorrect values are traced to their causes. Proper documentation is provided for establishment of the true values of lowest air temperatures, as of this date, for the coldest regions on the globe—the South Polar Plateau, northeastern Siberia, Greenland, and Canada.

### 1. INTRODUCTION

The recent reports of record-breaking temperature minima observed in Antarctica have prompted this investigation of previous minimum temperature records. Confusion has been present in the literature regarding this question and it is the aim of this paper to clarify the record. Documentation is provided to establish the true values of lowest air temperature for the coldest regions on the globe—the South Polar Plateau, northeastern Siberia, Greenland, and Canada.

### 2. MINIMUM TEMPERATURE ON SOUTH POLAR PLATEAU

Two successive record-breaking minimum temperatures were recorded during the 1957 winter season at the IGY Amundsen-Scott station at the South Pole. On May 11, 1957 [7] the temperature reached  $-100.4^{\circ}\text{F}$ . ( $-73.6^{\circ}\text{C}$ .) and near the end of the winter, on September 17, 1957 [8], a temperature of  $-102.1^{\circ}\text{F}$ . ( $-74.5^{\circ}\text{C}$ .) was recorded. This is, to date, the record low temperature for the world.

### 3. MINIMUM TEMPERATURE IN SIBERIA

The first temperature to be acknowledged as the "lowest in the world" was recorded by Neverov, a Russian merchant, on January 21, 1838, in Yakutsk (northeastern Siberia). It was observed on a Reaumur thermometer to be  $-48^{\circ}\text{R}$ . ( $-76^{\circ}\text{F}$ . or  $-60^{\circ}\text{C}$ .). This record was found by Middendorff [18] during his travels through Siberia. It is referred to also by G. Hellmann [11]. Prior to that time, no temperature that low had been reported even by the Polar expeditions. Absolute minimum records at that time were:

Floeberg Beach	82°27' N., 61°22' W.	$-58.8^{\circ}\text{C}$ . ( $-73.8^{\circ}\text{F}$ .)
Lady Franklin Bay	81°44' N., 65°03' W.	$-57.1^{\circ}\text{C}$ . ( $-70.8^{\circ}\text{F}$ .)
Fort Confidence	66°44' N., 119° W.	$-57.8^{\circ}\text{C}$ . ( $-72.0^{\circ}\text{F}$ .)

In the 1890's the "Cold Pole" at Verkhoyansk ( $67^{\circ}34'\text{N}$ .,  $133^{\circ}51'\text{E}$ ., elevation 107 m.) came to the fore. Unfortunately, however, the information about the lowest

temperature there has been confusing from the earliest report. H. Wild, the Director of the Physical Observatory in St. Petersburg reported in Russian [32] and German [33] sources that a minimum of  $-68^{\circ}\text{C}$ . ( $-90^{\circ}\text{F}$ .) was recorded in Verkhoyansk on January 15, 1885. He added the confusing remark: "Should we reduce the reading of the alcohol thermometer to the air thermometer, we would obtain, for the above mentioned minimum, a temperature of  $-76^{\circ}\text{C}$ ." ( $-105^{\circ}\text{F}$ .). There was no explanation for the reduction, or why so great a difference would be obtained. The Russian Meteorological Yearbook (Annales) for 1885 shows the minimum for January of that year as  $-67.1^{\circ}\text{C}$ . ( $-88.8^{\circ}\text{F}$ .). In view of this and the lack of explanation for Wild's reduction, we must discard Wild's figure of  $-76^{\circ}\text{C}$ . ( $-105^{\circ}\text{F}$ .) and accept the figure given in the Yearbook as the correct minimum for that year.

The next figure to appear in the literature as the "lowest in the world" was again at Verkhoyansk, in February 1892, when the absolute minimum for the month was observed on the 5th and again on the 7th as  $-69.8^{\circ}\text{C}$ . ( $-93.6^{\circ}\text{F}$ .). This value has been frequently quoted as the lowest temperature on record. It was, however, later corrected, as we shall see below.

In 1910 A. I. Voeikov [28] gave the minimum temperature at Verkhoyansk as  $-72^{\circ}\text{C}$ . ( $-97.6^{\circ}\text{F}$ .) for February 1892. Since this represented the "lowest temperature on earth" and was at variance with previous records, Prof. C. F. Marvin, Chief of the U. S. Weather Bureau at that time, requested an explanation of the data from Prince Boris Golitsyn at the Nicholas Central Physical Observatory, Petrograd. The answer from Prince Golitsyn [9] explained that neither the minimum of  $-69.8^{\circ}\text{C}$ . ( $-93.6^{\circ}\text{F}$ .) nor the figure of  $-72^{\circ}\text{C}$ . ( $-97.6^{\circ}\text{F}$ .) was correct. It suggested that Voeikov's error was most probably due to the fact that a correction of  $-2.0^{\circ}\text{C}$ . was added once more to the already corrected reading of the alcohol thermometer published in the Yearbook. The letter concluded, "The lowest temperature of air in

Verkhoyansk ought therefore to be considered as  $-68^{\circ}\text{C}$ . ( $-90.4^{\circ}\text{F}$ .) it is also the lowest temperature which has ever been observed on the stations of our meteorological net."

Thus, the round figure of  $-68^{\circ}\text{C}$ . was established as the "lowest on earth", and has been generally used in Russian textbooks since. The erroneous figure of  $-69.8^{\circ}\text{C}$ . has unfortunately continued to appear also, and this prompted E. Rubinshtein [22] to publish another explanatory article. She repeated the explanation given by Golitsyn and concluded: "The direct reading of the spirit thermometer on February 5 and 7, 1892, in Verkhoyansk was  $-67.8^{\circ}$ . Adding the instrumental correction of  $+0.2^{\circ}$ , we obtain  $-67.6^{\circ}$  which, in our opinion, must be taken as the most probable thermometer reading of these days."

An expedition, sponsored by the Academy of Sciences and headed by the geologist Sergei Obruchev, was sent to the Oimekon region, also in northeastern Siberia, in 1926, and discovered there a second cold pole. In his first communication [19] he remarked:

Temperatures of  $-50^{\circ}$  to  $-60^{\circ}\text{C}$ ., which set in by the end of November, greatly surprised us, for thus far it was supposed that the "Pole of Cold" (with temperatures to  $-69^{\circ}\text{C}$ .)<sup>\*</sup> was at Verkhoyansk; our observations permit the extension of the cold area as far as Oimekon, and possibly the transference of the pole itself to the latter place; but the solution of this question will only be possible after systematic observations during the whole winter.

Karl H. Pollog [21] mentions that Obruchev measured a temperature of  $-60^{\circ}\text{C}$ . in November near Oimekon. In a second article, Sergei Obruchev [20] states:

First of all, in order to avoid any misunderstandings, I must say that, up to this time, I have not published any exact data on temperature and those that appeared in my article were only some approximate figures. Our expedition was not supposed to take meteorological observations, and since it was planned to return to Yakutsk before winter set on, we had taken along only the mercury thermometers. Therefore, we could not measure any temperatures below  $-39.4^{\circ}\text{C}$ . (mercury freezing point) . . . we had to make use of some objective indications—namely of the rustling sound produced by the freezing breath, which is much like a sound of pouring grain. This phenomenon is called by the Yakuts the "whisper of stars." According to observations of Cherskii it appears at temperatures of  $-48.5^{\circ}\text{C}$ . and lower. During the period of very low temperatures, from the 10th to the 21st of November, I have heard this sound beginning from 6 p. m. on. This fact provided a reason why I was telling about the temperature as being from  $-50^{\circ}$  to  $-60^{\circ}$  (and not exactly  $-60^{\circ}$ , as it has been mentioned by C. Pollog).

Unfortunately it appears that the  $-60^{\circ}\text{C}$ . reference by Pollog was converted to  $-76^{\circ}\text{F}$ . and later appeared in the European literature as simply  $-76^{\circ}$  without reference to scale. An anonymous report [17] presumably communicating the results of studies by Prof. Sandström, speaks of the "frightening temperature of  $76^{\circ}$  below zero" at Verkhoyansk and says of Oimekon that "Professor Cherskii recorded the alarming temperature of  $78^{\circ}$  below zero at this desolated site." One can only assume that these temperatures, mentioned without reference to scale,

<sup>\*</sup>Obruchev is here using the wrong figure for Verkhoyansk.

TABLE 1.—Absolute minima of temperature ( $^{\circ}\text{C}$ .)

	Verkhoyansk	Oimekon		Verkhoyansk	Oimekon
January.....	-67.2	-65.6	July.....	-2.3	-4.4
February.....	-67.6	-67.7	August.....	-7.9	-7.1
March.....	-60.3	-56.7	September.....	-16.7	-17.8
April.....	-54.5	-46.3	October.....	-44.6	-35.7
May.....	-28.1	-25.4	November.....	-56.6	-62.2
June.....	-7.3	-5.8	December.....	-64.5	-64.4
			Year.....	-67.6	-67.7

are meant to be Fahrenheit readings. Published as they were in European publications, however, they were considered by other authors to be in  $^{\circ}\text{C}$ . They were quoted and requoted in various publications and gradually became established in the literature [6, 12, 15]. Since the observation at Oimekon was attributed to Cherskii, one can review his reports to verify the data. Such an examination, however, fails to reveal a value which could be interpreted as  $-78^{\circ}$  in any scale. Cherskii wintered in northeastern Siberia in 1891-92 and in his report [4] made only sparse remarks about the temperature. The lowest value which he mentions is  $-58^{\circ}\text{C}$ .

If we assume, as we must, that the reference to  $-78^{\circ}$  is erroneous, we must then determine what the true "lowest" temperature observed at Oimekon was. We know, that following Obruchev's suggestion, a meteorological station was set up in Oimekon in 1929. Since then some data obtained from observations taken by this station have been published in Russia, by prominent authors, presenting a reliable and also an official source of information. The greatest scope of data for Oimekon is found in the "Climatological Handbook for the Soviet Sector of the Arctic," Leningrad, 1940, edited by E. I. Tikhomirov [26]. In table 5 of this source are given the absolute minima of temperature for Verkhoyansk and Oimekon, which are reproduced here in table 1. These data were obtained from the actual series of observations for the period 1891-1920 in Verkhoyansk, and for 1931-1935 in Oimekon.

As we can see, even though Oimekon has a much shorter series of observations, it still came out with a little lower minimum than Verkhoyansk, and consequently, the title of the "Cold Pole" has been won by Oimekon.

In the same source we find also the mean monthly temperatures, year by year, and we reproduce them here (table 2) for the years 1931-1935, when both stations were working, for the colder months. As can be seen from table 2, the differences in the mean monthly temperatures between Oimekon and Verkhoyansk can be very great indeed; in single months Oimekon had a mean temperature lower by  $10^{\circ}$  to  $12^{\circ}\text{C}$ . than had Verkhoyansk.

If we compare the mean monthly temperature for the whole period of 5 years (1931-1935) for which we have the parallel observations of both stations, we obtain the differences ( $^{\circ}\text{C}$ .) in mean monthly temperatures between Oimekon and Verkhoyansk given in table 3. Only November was consistently warmer in Oimekon, but all the other months were colder.

TABLE 2.—Mean monthly and annual temperature (C.°)

Years	January		February		March		December		Year	
	Oimekon	Verkhoyansk	Oimekon	Verkhoyansk	Oimekon	Verkhoyansk	Oimekon	Verkhoyansk	Oimekon	Verkhoyansk
1931		-50.1	-49.5	-46.9	-27.5	-29.6	-50.3	-39.5		-14.2
1932	-50.9	-48.7	-45.6	-38.9	-32.5	-28.5	-49.6	-49.0	-16.8	-15.2
1933	-53.2	-40.6	-47.4	-47.8	-32.8	-33.5	-41.5	-46.8	-15.5	-14.6
1934	-47.1	-45.7	-44.3	-41.6	-33.6	-31.9	-47.6	-47.2		-14.9
1935	-50.8	-49.4	-49.1	-40.8	-34.9	-34.1	-42.8	-40.2	-15.4	-14.5

TABLE 3.—Difference between mean monthly temperatures (C.°) at Oimekon and Verkhoyansk, for period 1931-35. Minus sign equals colder in Oimekon.

January	-4.4	July	-1.9
February	-4.1	August	-1.1
March	-0.8	September	-1.1
April	-1.3	October	-1.6
May	-0.9	November	+1.5
June	-1.5	December	-1.9
		Year	-1.7

The absolute minima of  $-67.6^{\circ}\text{C.}$  ( $-89.7^{\circ}\text{F.}$ ) for Verkhoyansk, and  $-67.7^{\circ}\text{C.}$  ( $-89.9^{\circ}\text{F.}$ ) for Oimekon are also given in a later, and very important, work by Vize [27] which confirms their correctness.

The first one who published Oimekon's lowest temperature of  $-67.7^{\circ}\text{C.}$  was Salishchev [23]. In his article he gave a graph of the monthly mean, maximum, and minimum temperatures in Oimekon for the years 1930-1934, and stated: "... an absolute minimum for the four years of  $-67.7^{\circ}\text{C.}$  ( $-89.9^{\circ}\text{F.}$ ) was recorded on February 6, 1933." It is interesting to note the close coincidence of dates when the lowest temperatures were recorded at both places. In Verkhoyansk it was on the 5th and 7th day of February (1892), in Oimekon on the 6th of February (1933). Apparently the first 10 days of this month might be regarded as the most dangerous period in respect to cold in this area.

Most recently the correct lowest temperatures for Verkhoyansk and Oimekon were published in the United States by Stepanova [25].

Of course, scientists may wonder whether Russians have recorded some lower temperatures in recent years. A profound search through all Russian periodicals and most recent textbooks in meteorology has shown that the illegitimate figures of  $-76^{\circ}$  and  $-78^{\circ}$  have never crossed the Russian border and have never appeared in Russian sources. In the most recent textbooks on climatology, which had been approved and recommended for use in universities, the same old, round figure of  $-68^{\circ}\text{C.}$  (established by Golitsyn) still represents the lowest temperature on earth. Kostin and Pokrovskaja [14] gave the same value as the lowest temperature ever observed in the "Verkhoyansk-Oimekon Cold Pole region." Another recent textbook by Alisov, Berlin, and Mikhel' [1] is still more conservative; on p. 65 it says:

In the coldest years 1885 and 1892, the lowest temperature on the earth's surface was recorded in Verkhoyansk  $-68^{\circ}$ . In Oimekon, which is located on the plateau about 700 m. above sea level, the absolute minimum of air temperature might be still lower.

So, potentially, the Oimekon region has indeed all the advantages for originating the lowest temperatures. The orographic map in figure 1 shows the inner Oimekon Plateau as being a more elevated and at the same time more protected area than that of the Verkhoyansk region. Greater elevation stipulates a stronger cooling effect of the outgoing radiation since the re-radiation from the atmosphere usually decreases with height under the clear sky. But considering the fact that at low temperatures the outgoing radiation is generally small, the second factor weighs much more in the explanation of the strong cooling. The role of the mountain barrier encompassing the Oimekon Plateau and creating the extremely calm atmosphere over it seems to be of paramount importance in the origin of the lowest temperatures in this place. This conclusion is in accord with the evidence from the South Pole which indicates that the occurrence of the extremely low temperatures is primarily due to the establishment of such conditions where minimum mixing in the surface layer that contains the inversion is attained (Wexler [30]).

#### 4. MINIMUM TEMPERATURE IN GREENLAND

In comparing the lowest temperatures of the Greenland Ice Cap, it was found that the absolute minimum at "Eismitte" ( $71.2^{\circ}\text{N.}$ ,  $39.9^{\circ}\text{W.}$ , 2993 m.) as recorded by A. Wegener's [29] expedition on March 20, 1931, was only  $-64.8^{\circ}\text{C.}$  ( $-84.6^{\circ}\text{F.}$ ). F. Loewe [16] reported that "... the lowest temperature recorded on the Greenland ice sheet was  $-66^{\circ}\text{C.}$  ( $-87^{\circ}\text{F.}$ ) on 21 February 1950 at the French central station in lat.  $70^{\circ}54'\text{N.}$ , long.  $40^{\circ}42'\text{W.}$ , 2993 m. (9820 ft.)." However, on page 96 of the French publication of observations of the French station in Greenland [5], a temperature of  $-64.8^{\circ}\text{C.}$  ( $-84.6^{\circ}\text{F.}$ ) is found for February 22, 1950 (which is 9 p. m. of February 21, in Greenland). The coordinates are slightly different and there are no remarks concerning a correction of coordinates. The height is the same. It must therefore, be assumed that these are the best data (that are published in the station record), and that the lowest temperature observed by the Paul-Émile Victor expedition is exactly the same ( $-64.8^{\circ}\text{C.}$  ( $-84^{\circ}\text{F.}$ )) as that recorded during A. Wegener's expedition.

#### 5. MINIMUM TEMPERATURE IN CANADA

For Canada, the official lowest temperature is  $-81^{\circ}\text{F.}$  ( $-62.8^{\circ}\text{C.}$ ). It was observed on February 3, 1947, in

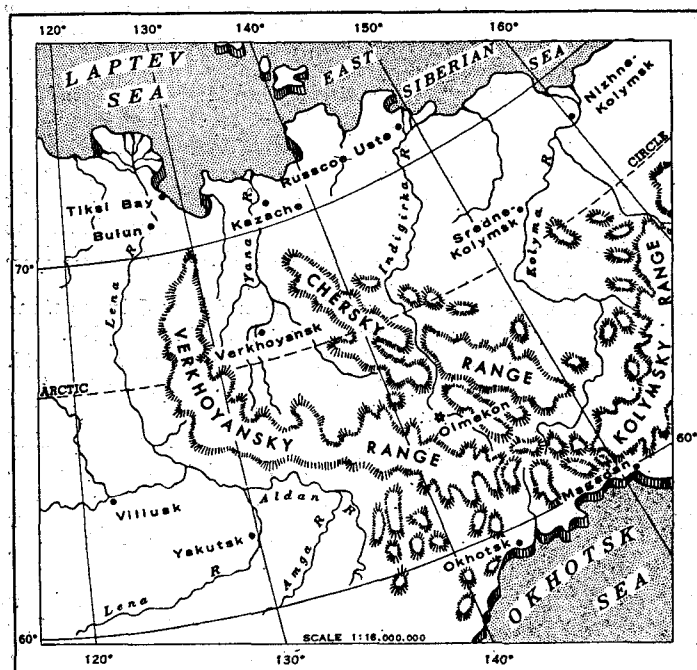


FIGURE 1.—Map of northeastern Siberia, showing the locations of Verkhoyansk and Oimekon.

the Yukon Territory at Snag,  $62^{\circ}23' \text{ N.}$ ,  $140^{\circ}23' \text{ W.}$ , elevation 2,120 feet (646 m.).

This absolute minimum was published in the official source of observation data *Monthly Record* [2], and was used in recent studies by Kendrew and Kerr [13]. It was also applied by Hare [10], who claimed, however, that the authenticated record was  $-81.5^{\circ} \text{ F.}$  (showing higher accuracy), but gave no evidence and no reference to the original source. Seamon and Bartlett [24] have investigated the meteorological extremes and have also found that the lowest official temperature ever recorded in Canada was  $-81^{\circ} \text{ F.}$  at Snag on February 3, 1947.

However, it should be mentioned here that a different minimum of air temperature was published in the *Monthly Weather Map* [3]. In tables on the reverse side of the map for February 1947, an absolute minimum of  $-83^{\circ} \text{ F.}$  is indicated for Snag, and the text of this issue states: "At Snag, Yukon Territory, a minimum temperature of  $-83^{\circ} \text{ F.}$  was reported which set a new low record for all Canada."

Thus in Canada, we have two official sources with conflicting data. An explanation of this fact is found in an article by Wexler [31]. A footnote in the article states that

... the lowest graduation on the Snag thermometer was  $-80^{\circ} \text{ F.}$  and by extrapolation  $-83^{\circ}$  was observed to be the minimum. The official Canadian records indicate the extrapolation was actually to  $-84^{\circ} \text{ F.}$ , but the Canadian authorities recognized  $-81^{\circ} \text{ F.}$  as the official minimum after having calibrated the thermometer and found an instrumental error of  $+3.0^{\circ}$  at that temperature.

The previous Canadian record low temperature was  $-78.5^{\circ} \text{ F.}$  ( $-61.4^{\circ} \text{ C.}$ ) observed at Ft. Good Hope [31] on December 30, 1910.

## 6. CONCLUSION

Thus, it has been established that there are four very cold regions on our planet: Yukon Territory, with the lowest temperature  $-81^{\circ} \text{ F.}$  observed at a height of 646 m.; Greenland, with the lowest temperature  $-84.6^{\circ} \text{ F.}$  observed at height 2993 m.; Oimekon, with lowest temperature  $-89.9^{\circ} \text{ F.}$  at height of about 800 m.; and the South Polar Plateau with the record breaking temperature of  $-102.1^{\circ} \text{ F.}$  at height of about 2800 m.

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